SEA SURFACE TEMPERATURE AND HEAT BUDGET VARIABILITY IN ECCO2

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INTRODUCTION

Oceanic mixed layer heat budgets are crucial for climate modeling efforts because they govern the evolution of sea surface temperatures (SST), the most important oceanic parameter driving atmospheric circulation. Mixed layer heat budget variability is controlled by surface heat fluxes, entrainment, advection, and diffusion:

$$\frac{\partial T}{\partial t} = \frac{1}{h}\frac{Q}{\rho C_p} - \frac{1}{h}\frac{\partial h}{\partial t}\Delta T + \text{advection} + \text{diffusion},$$

with T: mixed layer temperature, h: mixed layer depth, Q: surface heat flux ρ: density, C_p: heat capacity, ΔT: temperature difference between the mixed layer and the underlying layer.
For this study we concentrate on the heat flux (Q) and entrainment (E) terms, combining advection and diffusion into a residual term (R):

$$T = Q + E + R$$

The respective role of these processes varies as a function of region, spatial scale, and frequency. We present results from an analysis of mixed layer heat budgets in a 1992-2007 ECCO2 ocean state estimate.

SST - A PROXY FOR MIXED LAYER DEPTH?

One of the long-term goals of this study is to determine whether sea surface temperatures (SSTs) can be used as a proxy of mixed layer depth (ultimately analyzing satellite data). In the heat budget equation MLD is most prominent in the entrainment term. Although the entrainment term is clearly not dominating in most oceanic regions, SST and MLD changes show a high degree of correspondence. Fig. 2 shows a one-year time-series for a 5-by-5-degree box off the U.S. West coast. The correlation between these two time-series is -0.8. Similar values have been observed for various locations in the study area (with values of about 0.5 in dynamically active areas like the Kuroshio region). Preliminary analysis shows that these correlation values are similar for finer resolutions and different time scales (6-hourly and daily).

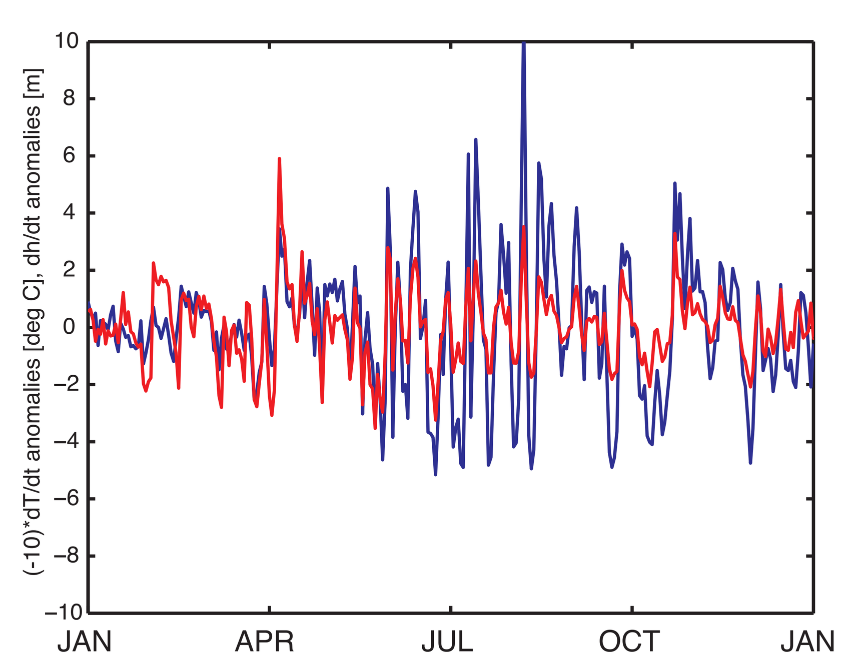

Figure 3: Time-series of daily dh/dt (blue) and dT/dt anomalies (red) for a 5x5° box off the U.S. West coast for the year 2002. dT/dt has been multiplied by -10 to emphasize the similarity of the graphs.

ML HEAT BUDGET VARIABILITY

We quantify the various contributions to changes in mixed layer temperature for the North and the Equatorial Pacific using monthly mean values. Fig.1 shows the contributions of surface heat fluxes, entrainment and the residual term for four seasons. Through most of the study area surface heat fluxes are the dominant term. Entrainment is only contributing in confined areas. The contribution of the residual term are most pronounced in the eastern equatorial region. All three term show high small scale variability.

T = Q + E + R

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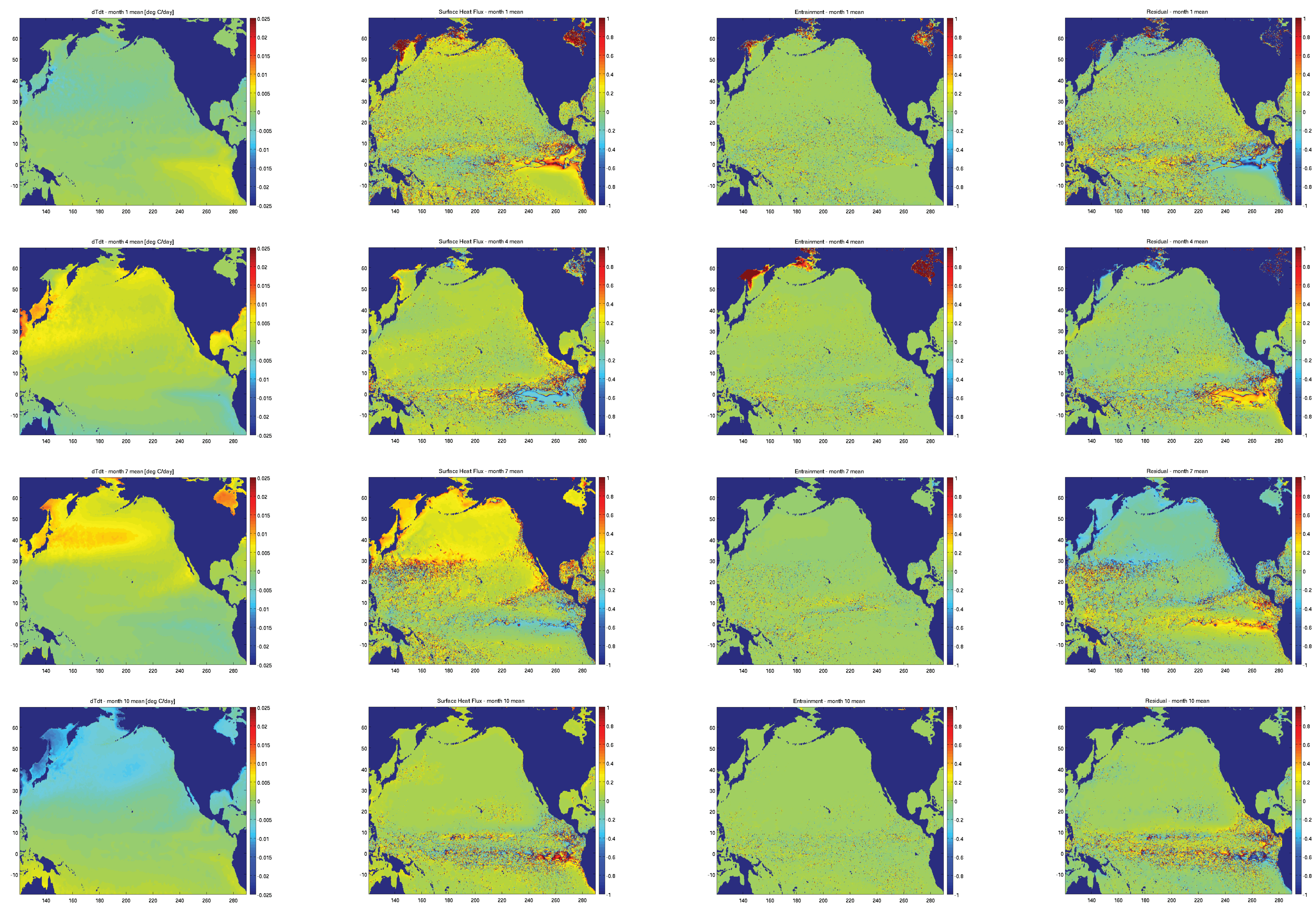

Figure 1: Heat budget terms for the months of January, April, July, and October. The values are means from 16 years (1997-2007) of monthly values. The first column show temperature changes in °C/day. The other columns show the respective contributions of surface heat fluxes, entrainment and the residual term normalized to the temperature change.

OUTLOOK

This work is a first step of a longer project that aims at not just quantifying heat budgets but also their associated errors. The next step will be a more structured regionalization with the goal of a simplification of the heat budget in terms of an identification of various regimes and frequency/wave number bands that are dominated by one or two of the heat budget terms. An integral part of this investigation is the mixed layer heat budget error analysis that will allows us to work towards improving the representation of mixed layer processes in ocean models.

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